URBAN AIR QUALITY AS A FUNCTION OF STREET DESIGNS;
STRATEGIES FOR COLOMBO TRANSPORTATION NETWORK
WITH SPECIAL REFERANCE TO GALLE ROAD

A Dissertation

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M.M.M.WEERASINGHE

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DECLARATION

I declare that this dissertation represent my own work, except where due acknowledgement is made, and that it has not been previously included in a thesis, dissertation or report submitted to this University or to any other institution for a degree, diploma or other qualification.

Signed: .....

M.M.M.Weerasinghe

Signed, Supervisor:

Dr. Rohinton Emmanuel

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ABSTRACT

The city of Colombo is gradually being choked to death by air pollution, especially vehicular related pollution. Poor air quality deteriorates human health, buildings and materials and even creates global environmental problems. The consideration and necessary attention towards cleaner air has been overshadowed by market forces in cities like Colombo. Much like most of developing cities, Colombo's city structure was influenced by colonial characters. These built forms have no bearing on natural, cultural and economical forces of the country. In addition, existing street network and space allocation is not enough to cater the ever rising transportation. As a result, transportation releases a considerable amount of pollutants to the air.

The study analyses the ambient air quality of CMR. Mount Lavinia Junction and Wadduwa were taken as the major sites, and analyses some variable factors in the city which could mitigate air pollution. At last the study is arrived at a set of conceptual street design strategies and guide lines to improve the air quality of the CMR.

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LIST OF ABBREVIATIONS

CO	Carbon Monoxide
CO_2	Carbon Dioxide
HC	Hydro Carbons
NO_x	Nitrogen Oxides
PM	Particulate Matter
PM_{10}	Particulate Matter with the size below 10 microns
$PM_{2.5}$	Particulate Matter below 2.5 microns
RPM	Reparable Particulate Matter
SO_2	Sulphur Dioxide
TSP	Total Suspended Particulate Matter.

INTRODUCTION

About fifty percent of worlds population is estimated to live in the tropics (Givoni; 1989) and it keeps rising. Much like many parts of the world, rapid urbanization can visible in most Asian cities, Colombo is no exception. Changes caused by urbanization on human include diseases associated with crowing, air pollution – related illnesses and psychological and emotional disorders (Harrison and Gibbs, 1976) Air pollution is one of the most serious phenomenon caused by rapid urbanization. Urban Air pollution in most cities has worsened due to the culminative effects of population growth, industrialization and increased vehicle use. Predominantly in non industrialized cities, transportation is the prime suspect for air pollution. The ever growing vehicle population and their high emission rates have been associated with serious air pollution problems in cities. As banister (2000) says,

> "Transportation is one of the largest sources of environmental pollution. The many significant environmental impacts associated with transport range from local to global and across."
>
> (Banister, 2000;175)

Colombo is the main commercial and business centre of Sri Lanka and as a consequence, many people are drawn into the city daily. Increased vehicle emissions in Colombo are one of the most important environmental issues that has drown the attention of policymakers, administrators, and environmentalists in the recent past. (Chandasiri; 1999, p-01) The city of Colombo is gradually being choked to death by motor traffic – related air pollution. According to current air quality monitoring data of CEA, Colombo's air is highly polluted compared to other urban areas (Perera, 2005; p - 01) The observed TSP, SO_2 and O_3 levels are now significantly higher than air quality standards recommended by WHO and Sri Lanka's Central Environmental Authority (CEA).(Chandrasiri, S. 1999)

Polluted air can cause variety of health problems including, breathing problems, reduced lung function, lung damage, asthma, bronchitis, cancer, nervous disorders and brain damage. Also

it causes irritations on eyes, nose and throat and reduces the resistance to other illnesses. Increase in Particulate pollution associated with increase in mortality.

Air pollution also causes serious environmental problems. Polluted air causes serious damages on animal and plant species in their extinction. It is also responsible for green-house effect and global warming phenomenon which change the climatic conditions of the world.

Air pollution can cause direct damage to various structure and materials, either by corrosion or by reducing the aesthetics value.

To mitigate air pollution, it is essential to check the degree of pollution. Hence, human exposure measurements and modeling is needed which they can tide up the connections between pollution exposure and possible effects of polluted air. Therefore exposure mitigation cannot under estimate. Even the country's economic growth can be affected from the adverse effects of air pollution where health and environmental costs could act as negative externalities.

Urban transportation is a function of the overall city form and urban air pollution it a function of transportation. In this manner urban designers are responsible to produce urban built forms which produce less pollutant as well as to improve city's air quality. Urban design is a piece-meal activity. As a poor country we cannot afford money to re-design the city of Colombo. Therefore design solutions have to be presented as implement-able strategies. The strategies and guide lines would improve the quality of small and medium towns which intern improve the quality of life in the CMR.

This thesis will investigate urban street design strategies in terms of air pollution mitigation in an urban location of Colombo Metropolitan Region (CMR). Air pollution trends in urbanization process will be discussed in the background chapters (chapter 01 and 02) Air quality monitoring and analytical framework will be formulated in chapter 3 and 4. Chapter 5 is arriving at as set of conceptual street design guidelines to improve the air quality towards higher urban quality of life.

Goals and Objectives

The study is focused on human exposure and adverse effects from Respirable Particulate pollution, and gives guidance to develop urban street design strategies to improve the quality of life in the CMR. The goals of the study are, as follows;

- Measure actual human exposure to polluted air
- Identify sub elements of the exposing dust
- Identify hours of high level dust exposure
- Develop street design strategies and guide lines to mitigate exposure to Respirable Particulate pollution

These strategies then could use as generic guide lines for other cities in the tropic where climatically economically and culturally the same.

Scope and Limitations

Vehicular related air pollution can mitigate by using several procedures such as improved vehicular technology, vehicular maintenance, fuel quality improvements' taxing, and policies etc. But this thesis discusses only the architectural implications and strategies. Therefore, the analytical framework will be formulated to investigate the effect of metrological factors (such as vehicle volume, temperature, wind speed, relative humidity, locational factors etc.) on RPM

The Mount Lavinia Junction and the Wadduwa junction were taken as the major case study sites where they are two different points on the major urban street of the Colombo Galle road. Highly polluted Mount Lavinia junction (High risk busy town) was taken for further analysis of TSP, RPM,sub elements and hourly measurements.

Due to the lack of required instruments and man power the measuring took a very long time. Owing to the above factors the study restricted only for mount Lavinia and Wadduwa.

Finally the investigation ends with several urban street design strategies in terms of air pollution which could be used to improve the air quality of the CMR. However for a better outcome, all the stakeholders have to involve and perform together

Methodology

- Study the existing urbanization trend in relation to the City Form and Transportation in Colombo Metropolitan Area.
- Select two different sites on the major urban street (The Galle road) of Colombo based on the activity pattern and the risk of pollution levels. (High-Risk Busy town and Low-Risk Suburb)
- Gather data on major air pollutants, vehicle volume, and other micro-climatic conditions such as Temperature, Relative Humidity (RH), Wind speed etc.
- Find out the existing pollution levels (ambient air quality) of the sites.
- Using the data gathered, find out the reasons and relationships for the air pollution and find out the reasons for the variations. (PM vs. Variables).
- Arriving at a set of research conclusions in terms of the analysis protocol.
- Develop a set of street design strategies and guide lines to mitigate the exposure to pollutants.

Methodology is discussed in detail in the chapter 3.0; Method and Materials.